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(54) Title of the Invention: Optical system of LSI fabrication reduction projection lithography apparatus by light

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(54) Abstract

[Object]

It is to obtain a mirror-type stepper with the light source of the ultraviolet light at the short wavelengths, the deep depth of focus, the broad exposure area and the large numerical number.

[Configuration]

The light source is arranged at one focus point of revolving elliptic concave mirror, and small opening 8 of plane mirror 7 is arranged at another focus point thereof, and small opening 8 is also the focus point of parabolic mirror 10.

[Effect]

With the high-coherent light as the light source, the depth of focus is made deeper to eliminate various aberrations, and the effective numerical aperture is improved. Furthermore, by making the reticle image larger than the image on the wafer, and making the wavelength bandwidth of the illumination light broader, the degradation of the image by use of the high-coherent light is prevented. In this case, the resolving power is improved when the space among the optical system is filled with the transparent liquid.

[What is claimed is]

[Claim 1]

An optical system of a LSI fabrication reduction projection lithography apparatus comprising:

an illumination unit of converging light on one point in front of a reticle; and

a plane mirror being arranged by aligning a small opening of the plane mirror with the one point on which the light is converged, wherein a mirror with a concave surface facing to a mirror surface of the plane mirror is arranged.

[Claim 2]

The optical system of the LSI fabrication reduction projection lithography apparatus set forth in claim 1, wherein the optical system is configured to fill a space of the optical system with a transparent liquid, and circulate the transparent liquid.

[Detailed description of the Invention]

[0001][Field of the Invention]

The present invention relates to an optical system of a mirror-type LSI fabrication reduced projection lithography apparatus (a stepper) by means of light.

[0002][Prior arts]

There has been the conventional mirror-type 1:1 magnification batch projection lithography apparatus or the lens-type stepper.

[0003][Problems to be solved by the Invention]

In the optical system of the mirror-type 1:1 magnification batch projection lithography apparatus in the prior art, only the line image at 1:1 magnification can be attained, so this system has had the problem that it is quite difficult to make the fine alignment of the mask image, and the effect of the dust becomes large, and it is difficult to remedy all the defects or the like.

[0004]

In the conventional lens-type stepper, the transparent substance in the lens usable in the ultraviolet light at the

short wavelengths is few, and the transparency of the lens is low, or there is another problem on the endurance of the lens.

[0005]

An object of the present invention is to provide a stepper having a mirror-type optical system capable of using the ultraviolet light at the short wavelengths, and having a high resolving power and deep depth of focus with a broad exposure area.

[0006][Means for solving the problems]

In order to attain the above object, in an optical system of a stepper according to the present invention, high-coherent light with a relative broad range of the wavelengths as a light source is caused to be converged on one point in front of a reticle by a condensing mirror with a concave surface, and

[0007]

A plane mirror is arranged by aligning a small opening of the plane mirror with the one point on which the light is converged, and

[0008]

A mirror with a concave surface facing to a mirror surface of the plane mirror is arranged in such a manner that a focus point of the concave mirror is aligned with the small opening of the plane mirror.

[0009]

Light from the light source is illuminated on a reticle, and passes through the small opening of the plane mirror, and turns into almost collimated light on the concave mirror, and a very thin transparent window plate is arranged perpendicular to the traveling collimated light reflected on the same plane mirror, and

[0010]

A wafer is loaded very close to the transparent window plate, and a reticle image is reduced and formed on the wafer.

[0011]

The reticle is fabricated on a curved surface correcting for curvature of field.

[0012]

A space among the optical system is filled with a transparent liquid, and circulating the transparent liquid is very effective due to a later-described reason.

[0013] [Action]

Assuming that light passing through the reticle is high coherent, and a wavelength is λ, a diameter of condensing concave mirror is D, and a focal length is f, 84.6 % of all of a light amount is converged on the small opening of the plane mirror in front of the reticle within a radius of $\gamma = 1.22\lambda f/D$. A diffraction pattern of the reticle occurs around its perimeter.

[0014]

According to the present invention, as the reticle and the transparent window plate are made from synthetic fused silica, their surfaces can be smoothly grinded, whereby an effect of the surface by use of the high-coherent light is low.

[0015]

According to the present invention, an outside is insulated by the transparent window, so convection of air is few, and moreover, an entry of the dust is prevented. When the present invention as a whole is configured with a near-vacuum structure, the convection of air and the effect of the dust become small.

[0016]

On the contrary, by filling the space among mirror optical system with the transparent liquid, and circulating this transparent liquid, the effect of the surfaces of the reticle and the transparent window plate become small, and moreover, the effect of the dust becomes small. As the light is absorbed by the transparent liquid, a change in refractive index of light due to increase in temperature is prevented.

[0017]

As the transparent window is very thin, and arranged perpendicular to the light reflected on the concave and plane mirrors, chromatic aberration does not occur.

[0018]

According to the present invention, an electric dust collector is arranged at the perimeter of the small opening of the plane mirror between the plane mirror and the reticle, so the dust in the stepper is eliminated, and the entry of the dust into the mirror optical system through the small opening of the plane mirror is prevented.

[0019]

According to the present invention, the more an image pattern on the reticle has transparent parts, the better the image pattern becomes, so it is necessary to take this into account upon image-formation. Depending upon the image pattern, there may be a case where it is better to invert a photoresist image.

[0020]

In the LSI fabricated by the stepper of the present invention, a deficit portion corresponding the small opening of the plane mirror exists at the center, but the small opening is the order of 1 mm in diameter, there is no effect on LSI chip density. When the light amount of the light source can be made large, it is a matter of course that the diameter of the small opening can be set to be further smaller.

[0021][Preferred example embodiments]

Example embodiments being made with reference to accompanying drawings, in Fig. 1, xenon lamp 1, filter 2, slit 3, revolving elliptic concave mirror 4, reticle 5, small opening 8 of plane mirror 7, parabolic mirror 10, plane mirror 7, transparent plate 11 and wafer 12 are arranged in order of this sequence along an optical path of the light from xenon lamp 1, and at one focus point of the revolving elliptic concave mirror is arranged slit 3, and at another focus point thereof is arranged small opening 8 of plane mirror 7. Furthermore, small opening 8 is concurrently a focus point of parabolic mirror 10, too. In this case, mirror surface 9 of plane mirror 8 is arranged facing to parabolic mirror 10, and electric dust collector 6 is attached to the perimeter of small opening 8.

[0022]

Instead of xenon lamp 1, there is an example embodiment using an excimer laser causing an oscillated wavelength to be excited by mixing several kinds of gasses like ArF, KrF, etc. as the light source.

[0023]

There is an example embodiment using a lens for aberration corrections instead of transparent window plate 11.

[0024]

There is an example embodiment using another concave mirror such as a spherical mirror, a hyperboloid mirror, etc. instead of parabolic mirror 10.

[0025]

According to an example embodiment shown in Fig. 2, the space among the optical system is filled with the transparent liquid, and the transparent liquid is caused to be circulated. Reticle 5 is immersed in tank 13 filled with the transparent liquid.

[0026] [Effect of the Invention]

As the present invention is configured as described above, the following effects described below are attained.

[0027]

As the light source for the reticle illumination uses the high-coherent light, and the light is caused to be converged on the one point in front of the reticle by the revolving elliptic concave mirror, 84.6 % of all of the light amount is converged on the small opening of the plane mirror in front of the reticle within the radius of $\gamma=1.22\lambda f/D$ where the wavelength is λ, the diameter of the revolving elliptic concave mirror is D, and the focal length is f. The diffraction pattern of the reticle occurs around the perimeter of the small opening, but the center point of the small opening is very high in the light amount in comparison with a perimeter ring-shape fringe portion having a light wavelength width at the small opening, so the rate of the diffraction occurrence due to the light passing through the fringe portion of the small opening becomes very low. Therefore, reduction in resolving power due to the light passing through the small opening is very small. This effect is getting larger

as a size of the small opening is close to the radius of $\gamma = 1.22\lambda f/D$.

[0028]

Most of the light reaching each point of the images on the surface of the wafer are the light reflected at a corresponding very tiny range of the parabolic mirror, so that depth of focus is also deep, and the aberrations other than the curvature of field and a distortion becomes very small.

[0029]

Furthermore, most of the light reaching each point of the images on the surface of the wafer are the light reflected at the corresponding very tiny range of the parabolic mirror, so that an effective numeral aperture becomes larger than the mathematical numeral aperture of the parabolic mirror.

[0030]

With the high-coherent light as the illumination light source, a speckle noise, etc. is brought about due to a diffraction phenomena of the reticle image, but the present invention is a type reducing the reticle image up to the order of 1:10, so that the reticle image pattern can be made large and no chromatic aberration allows the wavelength width to be broader, whereby there is no degradation of the image even if the high-coherent light is used as the light source.

[0031]

With the stepper of the present invention, the exposure area of the order of ϕ30 mm, and the mathematical numerical aperture of the order of 0.35 (the effective numerical aperture is much larger) can be attained.

[0032]

As the present invention uses the mirror-type optical system, the ultraviolet light at the short wavelengths can be used than the stepper using the lens-type optical system.

[0033]

By filling the space among the optical system with the transparent liquid, the same effect as light of λ/η is used can be attained where the wavelength of the light is λ, and the

refractive index of the transparent liquid is η.

[Brief description of the drawings]

Fig. 1 is a schematic block diagram of one example embodiment of the present invention.

Fig. 2 is a schematic diagram of the reticle fringe portion of the example embodiment where the optical system of the stepper of the present invention is filled with the transparent liquid.

[Description of the reference codes]

1 XENON LAMP
2 FILTER
3 SLIT
4 REVOLVING ELLIPTIC CONCAVE MIRROR
5 RETICLE
6 ELECTRIC DUST COLLECTOR
7 PLANE MIRROR
8 SMALL OPENING
9 SURFACE OF PLANE MIRROR
10 PARABOLIC MIRROR
11 TRANSPARENT WINDOW PLATE
12 WAFER
13 TANK FOR FILLING TRANSPARENT LIQUID
14 TRANSPARENT LIQUID FLOW FILLING OPTICAL SYSTEM